



Circular construction

Most opportunities for demolishers and wholesalers

Sustainable transitions | circular economy



Corporate Member Ellen MacArthur Foundation



Summary

Circular construction involves the entire supply chain

Environmental impact reduced by circular construction

Buildings produce CO₂ emissions in two ways:

- During use through heating and etc. (approx. 35% of the total EU CO₂ emissions);
- During the construction and manufacture of the building materials (approx. 5% of the total EU CO₂ emissions).

New buildings are now almost energy neutral or they even generate energy on balance. From 2020, new EU standards will apply for new buildings requiring these buildings to be energy neutral when in use. However, customers are more often demanding further reductions in the environmental impact of buildings. These can be achieved by making the construction process and the manufacture of building materials more sustainable as well. At the basis of this is circular construction with focus on the reuse of building materials.

Circular construction involves the entire supply chain

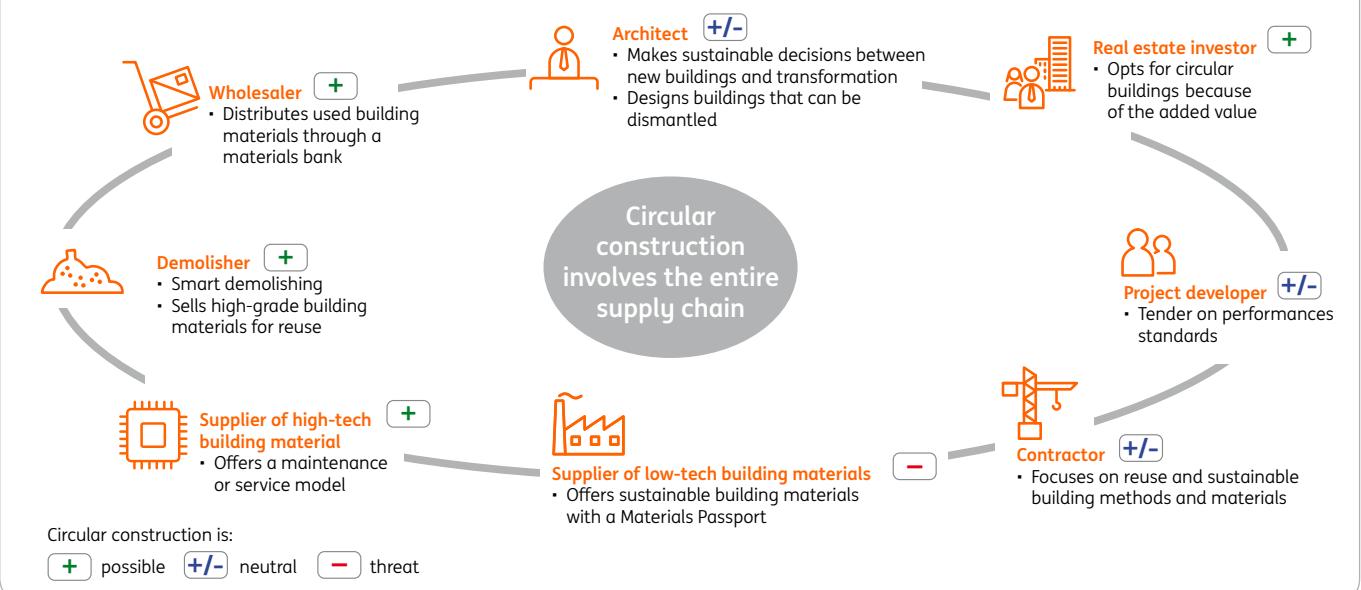
To achieve circular construction, the entire construction supply chain needs to be involved. For example, architects and owners decide whether to reuse or demolish an old building. Construction suppliers offer bio-based building materials. Smart demolition (dismantling) allows demolishers to offer high-grade used building materials for reuse. Wholesalers can take on the role of resources banks, selling used materials.

'Product as a service' only for high-tech building materials

A circular model can have an impact on the business model. Companies guarantee a performance at a periodic fee and

Activities of supply chain partners in circular construction

Circular construction has consequences for all supply chain partners



no longer deliver a product but a service. The manufacturer retains control over this product. Smart design facilitates effective reuse. In the construction industry, this model is particularly suitable for high-tech products such as lifts and climate control systems. The complexity of these products gives the supplier a knowledge advantage with the result that the supplier is usually in a position to provide efficient maintenance.

More circular innovation without nailed-down specifications

Customers have an important role in ensuring that as much circular innovation as possible is generated along the entire construction supply chain. Ideally, the invitation to tender should be as broad as possible. This allows each supply chain partner to tender their innovative circular construction methods rather than having these methods nailed-down in set specifications allowing no room for innovation.

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In recent years, energy savings in built-up areas have focused on reducing consumption during use (heating, lighting and so on). Less attention has been given to energy consumption in the construction process and in the manufacture of building materials. Now, more and more new buildings are almost energy neutral or even, on balance, generate energy.

To make new buildings even more environmentally friendly, the next step is to tackle the construction process and the building materials. This can be achieved with a circular system based on the reusability of products and resources. The aim is to reduce waste and CO₂ emissions and to develop buildings that hold their value. This publication examines how this can be applied in the construction process. The following questions are addressed: What is circular construction? Is there a demand for circular construction? How does circular construction work? What are the limitations and for which supply chain partners are there opportunities?

In this study, we focus wherever possible on the circularity of the building materials used in the building and less on the consumption of energy during the use of the building.

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1. What is circular construction?

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What is circular construction?

Circular construction is more than recycling

From a linear to a circular economy

In the traditional linear economy, little attention is given to the social cost of waste and CO₂ emissions. In a circular economy, products and materials are reused wherever possible and residual waste kept to a minimum. This can be achieved through:

- Reuse of the product by another user;
- Increasing the life span (through good maintenance and repair);
- Reuse of product parts.

This can lead to new business models in which suppliers continue to own the products and users simply purchase a service.



Rethinking finance in a circular economy

[Financial implications of circular business models]



ING Economics Department

For a detailed analysis of the circular economy in a broad sense and its implications for financing, see the report 'Rethinking finance in a circular economy'.

Circular construction: minimum use, maximum reuse

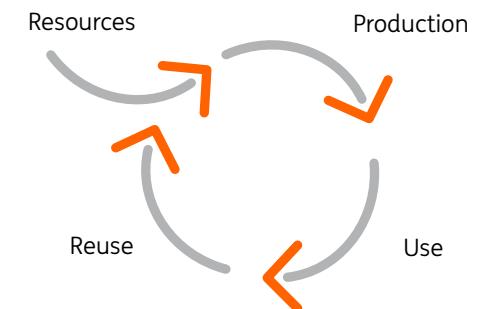
Circular construction involves the entire construction supply chain. In other words, it is not only working out how the materials can best be reused when a building is demolished. In circular construction, architects, engineers and contractors take minimising the use and maximizing the reuse of entire buildings and/or building materials into account at the very start of the construction process.

Linear and circular economy

Linear economy



Circular economy



Sources: TNO and Ellen MacArthur Foundation,
edited by ING Economics Department

What is circular construction?

High-grade and low-grade circular construction

Focus on holding value

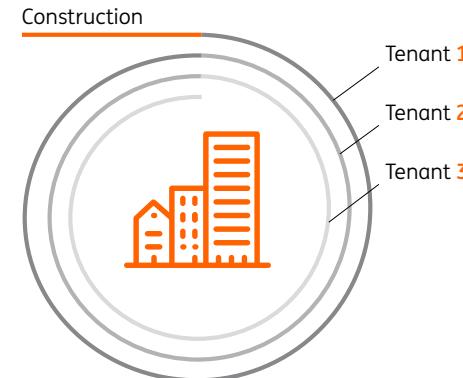
There are many different circular construction methods (p. 7). The current accent on recycling largely destroys the added value of building materials and reduces this to the value of the resources. As a result, this is also referred to as downcycling. It is better to reuse high-grade building materials or indeed even complete buildings or parts thereof. In the construction sector, this can often be done through transformation or renovation of a complete building. In fact, recycling should only be used as a last option. For instance a frame has a much higher value than the wood it is made of. The circular economy is about holding as much value as possible. The shorter the cycle, by reusing the product with as few modifications as possible, the better.

Frequent low-grade reuse due to low resource costs

Low-grade reuse of construction waste usually occurs because, in the past, in the design phase, no account has been taken of the reuse of building materials. As a result, it is often difficult to separate waste materials and these are reused as rubble. Additionally, resources that are frequently used in the construction sector, such as sand, grit and clay are plentiful, which keeps prices low. This makes reuse less appealing. Therefore, high-grade circularity of building materials is often technically and economically unattractive.

Circular process Real Estate market (reuse)

The use of real estate is often a circular process. Many tenants make consecutive use of a building.



Leasing real estate is a high-grade circular process

If we look at the real estate sector as well as the construction sector, we see that in fact a high-grade circular process already exists. The owner (the investor) makes the building available to a series of tenants, with no or very few modifications. There are few products that last as long as real estate. There are monumental buildings that have been in use for centuries. Few other goods have such a long life span.

The difference between high and low-grade construction

High-grade circular construction

- Maximise life span by product reuse: re-rent or sell a property (**reuse and maintain**)
- Use fewer or bio based building materials (**reduce**)
- Repair by renovation or transformation (**repair**)
- Reuse materials by 'smart' demolishing / dismantling (**recycle**)
- Demolish and reuse at resource level (**down cycle**)

Low-grade circular construction

What is circular construction?

Many different methods

There are many different ways to make construction circular. Circular construction has become a container concept. Some methods and what they are suitable for are listed below.

Method	What is it?	Who applies it?	Level	Sort of circularity	Suitable for:
					New buildings Existing buildings
Circular design	Circular construction starts with circular designs. When designing, the architect already takes into account the changing use. All the methods listed here can be used with this.		Architect and client	High	Re-use 
Maximise life span	Use a building for a long period of time so that the materials remain in use. For example, the Amsterdam canal area has been in use for centuries. Good maintenance significantly increases the life span of the buildings.		Architect and project developer	High	Re-use & maintain 
Construct demountable buildings (LEGOising)	Design and construct a building in such a way that the building materials can be easily dismantled and reused.		Architect	High	Re-use 
Design buildings with fewer materials	By using fewer materials, there will ultimately be less waste and lower CO ₂ emissions.		Architect and suppliers	High	Reduce  
Bio based construction – building materials	Construct using natural building materials such as wood. Renewable and therefore inexhaustible sources for materials are used.		Suppliers	High	Reduce  
Transformation	When a building is no longer suitable for the current use, it can be transformed. Limited use of new (circular) building materials gives the building a second life.		Architect and project developer	Average	Repair 
Materials bank	When a building cannot be transformed it can serve as 'resource / building block' for other building structures. Reusing parts has preference over reusing material in order to hold as much value as possible		Wholesaler and demolisher	Low	Recycle  
Demolish and recycle	If a building cannot be transformed or dismantled into separate components, it can often only be demolished with (low-grade) reuse of the resources.		Demolisher	Low	Recycle  
Resources passport	A resources passport records at molecular level what resources are used in the building or building materials and how many. In the Building Information Model (BIM), the resources used are recorded and can be passed on from supplier, contractor, owner and finally to the demolisher/dismantler.		Suppliers	Low	Recycle  



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Why circular construction?

Next step towards energy neutral buildings

The construction phase and building materials are not yet energy neutral

Today, more and more new buildings are almost energy neutral or on balance they even generate energy. From 2020, new EU standards apply for new buildings that require buildings to be almost energy neutral when in use. To make further energy savings and to reduce CO₂ emissions in urbanised areas, the construction process and the manufacture of building materials could also be tackled. These are currently responsible for approximately five per cent of all CO₂ emissions in the EU. These CO₂ emissions are also minimised in circular buildings. Additional legislation could require the market to introduce circular construction.

Construction activity and building materials responsible for about:



5% of the total EU CO₂ emissions

This 5% should not be confused with the approximately 35% that is used for heating and electricity consumption in the urbanised areas.



35% of the total EU waste flow

A large part of this construction waste is recycled. However, this is often done low-grade. This largely concerns rubble that is processed into granules used for road foundations.

Source: CE Delft European Commission and RWS, edited and estimates by ING Economics Department

Why circular construction?

Increasing demand for circular buildings

Research conducted by the University of Maastricht and ING Real Estate Finance shows that energy-efficient office buildings have approximately 9% higher value. Full circularity of buildings can add even more value to this. Users and customers are therefore increasingly demanding that buildings are circular in addition to sustainable when in use:



Large companies and multinationals are demanding circularity

Large corporate companies are attaching increasing importance to sustainability. They also want to make their company buildings circular. Circularity is more often part of CSR policy. Medium and small enterprises are also becoming more aware of this. Medium and small enterprises often deliver supplies to corporate companies giving them the opportunity to advertise their sustainability achievements.



Added value for investors (although they often do not yet see this)

A building constructed according to a circular method has added value for investors. The purpose for which buildings are used changes with increasing regularity. For instance, office buildings are transformed to apartments or hotels. A building that can be converted easily and inexpensively to another function has more value than a one-purpose building. As a result, the investor knows that when the current tenant's lease is terminated, it will be relatively easy to re-let the building, possibly for a different use. However, investors' relatively short-term investment visions of between five and ten years and the highly limited or total absence of appreciation of this added value by surveyors often still form an obstacle here.



High ambitions at local authorities

As part of their social role, provinces, municipalities, the Department of Public Works (Rijkswaterstaat) and housing corporations can play a leading role in circular construction (see the example on p. 13). These are mainly infraprojects where (quasi) government agencies are the customers. It is estimated that this accounts for about 20% of the total annual European (EU 19) construction output.



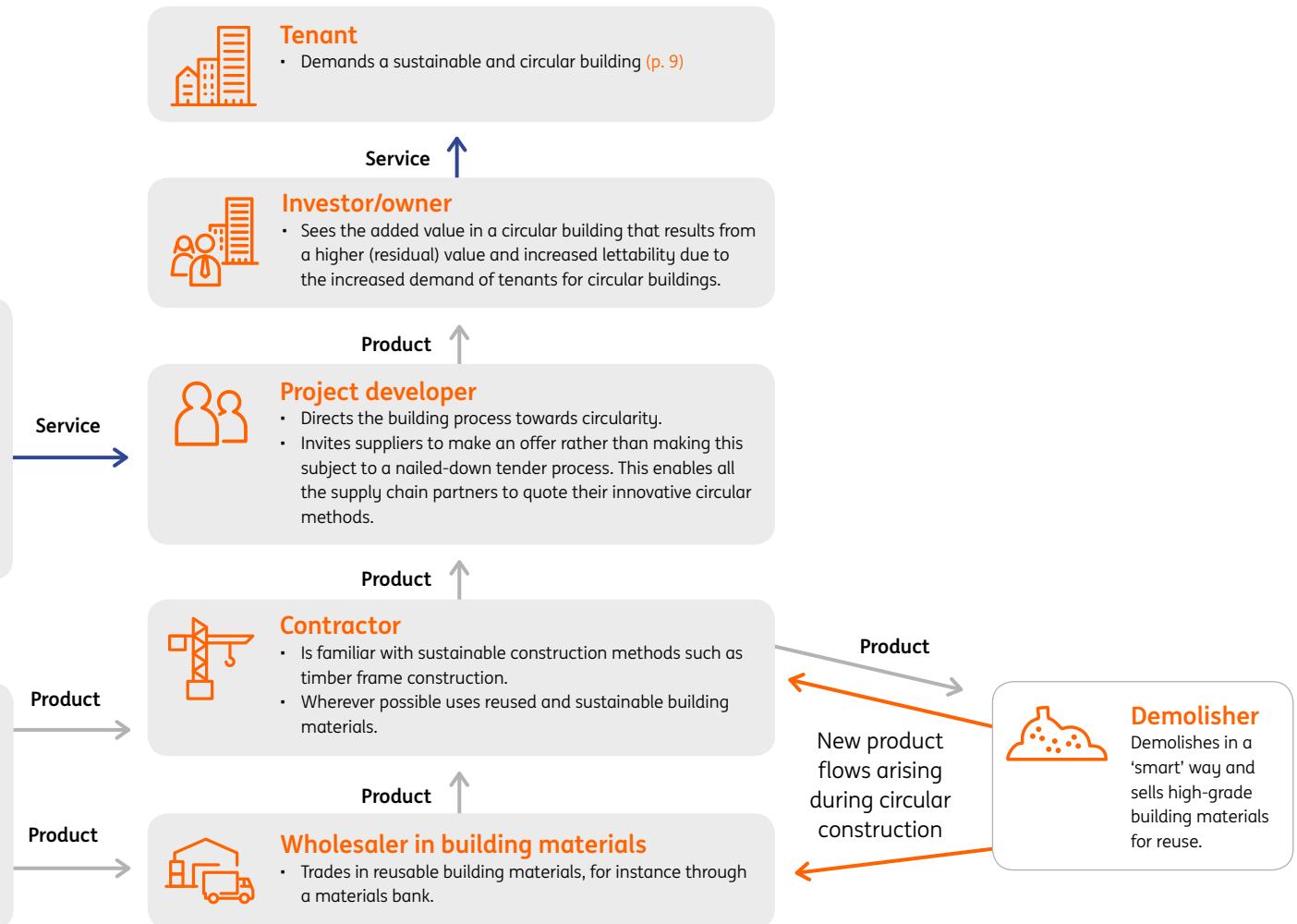
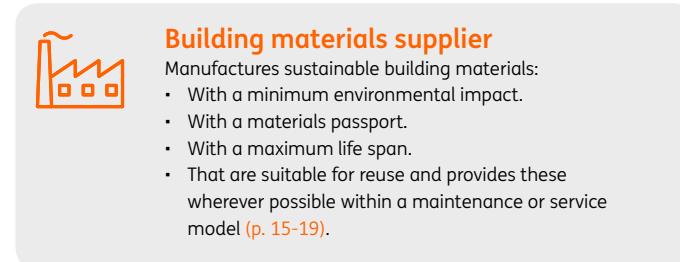
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How does circular construction work?

Who does what?

For circular construction to be as high-grade as possible, the business model of all the supply chain partners has to change. The chart below summarises the most important changes.



How does circular construction work?

All the supply chain partners are involved

Circular model: entire supply chain involved

High-grade circular construction needs the involvement of the entire construction supply chain. Architects and owners decide whether an old building will be reused or demolished and how a building can be easily converted for a new use. Suppliers can offer bio based materials and demolishers ensure that building materials of the highest possible grade are reused. All the supply chain partners, from owner and architect to demolisher, need to embrace the circular principles for this to be a success.

Modular construction as step towards circular construction

The trend of modular construction brings us a step closer to achieving circular construction: an efficient (standardised) production method for delivering customer-specific and flexible buildings. Under this construction method, buildings are constructed using materials that are easy to dismantle. This makes replacement, reuse or recycling significantly easier and less expensive. During reuse, the design holds its value and not only the (more limited) value of the material. This process starts at the builder's and the architect's drawing board.

Dispense with nailed-down tenders

To enable the entire supply chain to offer innovative circular solutions, customers would do much better to issue a generally worded invitation to tender explaining what requirements a building should meet rather than holding a

tender procedure based on final, nailed-down specifications. This allows each partner in the supply chain to quote its own circular construction methods rather than having methods imposed on it. In projects where this is done, applicants often surprise the customer with, for instance, environmental performances that are even better than the minimum requirements. For example during the tender for the Alliander head office in the Netherlands, suppliers were invited to make quotes for an energy-neutral building. VolkerWessels surprised everyone by proposing an energy positive building.

Margin on trade in second hand building materials is still small

The smart design of parts or modules can make used materials less expensive than new. This is particularly true when proper maintenance guarantees long-term quality. However, in practice, this purchase advantage continues to be (virtually) unattainable. For decades, processes for new building materials have been optimised with the result that the costs are relatively low. Furthermore, the prices of resources are so low that in terms of purchase and production costs alone, in 2017, the circular model usually still loses out to the 'linear' model. However, the increased demand, the willingness to pay more and the increased efficiency of the circular process could cause the margins in trade in second hand building materials to go up in the coming years.



"Circular construction needs the involvement of the entire supply chain. Everyone, from customer to contractor, should ask each other: Can we do it differently? Is circularity possible? Can we make energy positive buildings? Very many things have been possible for a long time, but you do have to ask for them."

Onno Dwars, Ballast Nedam Development.

SPACES4YOU
workspace creators

Reuse of inner walls

Spaces4you gives a new lease of life to existing inner walls on business premises. According to one of the founders, Jerry van Hekken, the reuse is up to 50% cheaper. The condition is that the inner walls are directly usable. Once materials for reuse have to be cleaned, stored and so on, it is often no longer profitable and new inner walls are less expensive.

How does circular construction work?

In practice: Venlo town hall and New Horizon

Venlo's new town hall in line with basic principles of circularity

At the start of the project, the municipality concentrated on creating a design team in the Netherlands with the right mind set with regard to sustainability. The target was to construct a building using only reusable materials that generates energy, purifies water and improves air quality. The materials used will not end up on the scrapheap but are given a new lease of life.

“Once we had agreed with the supplier that after 20 years it would buy back the building materials, we were suddenly offered free maintenance.”

To optimise reuse, we agreed with several suppliers that they would be willing to buy back their materials (for example furniture) after some years at pre-set prices. This creates a continuous cycle of resources. To achieve this, almost everything can be



dismantled. There are several cycles in the building. The south façade is constructed using aluminium and is fully reusable without losing any of its value. The biological north façade consists largely of plants and greenery.

NewHorizon
URBAN MINING

“We don't demolish, we harvest.”

Michel Baars, representing the Dutch company New Horizon, believes in the circular economy as an economic model, not as sustainability 3.0. 'The circular economy is not more expensive, it does not take longer and is much more fun' he says. New Horizon sees the city as a source. The urbanised area is the warehouse and is full of usable resources and can be used to mine resources (urban mining). Buildings are dismantled and the materials hold their value. In five years, Baars aims to buy demolition works rather than being paid to demolish them. New Horizon works in partnership with the housing corporation De Alliantie, among others. It demolished, for example, an empty office block adjacent to Alliantie's current head office. The harvest, including window frames and floor tiles were reused in other projects. Reusing materials is not yet commonplace in new buildings. By using strong partners, Baars is trying to deliver hybrid materials (a mix of reused and new materials) wherever possible with the aim of making the share of reused materials as large as possible. In this way, the share of reused materials used during management, renovation, transformation and in new buildings will gradually increase.



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What role does 'from ownership to use' play?

Maintenance and 'from ownership to use'

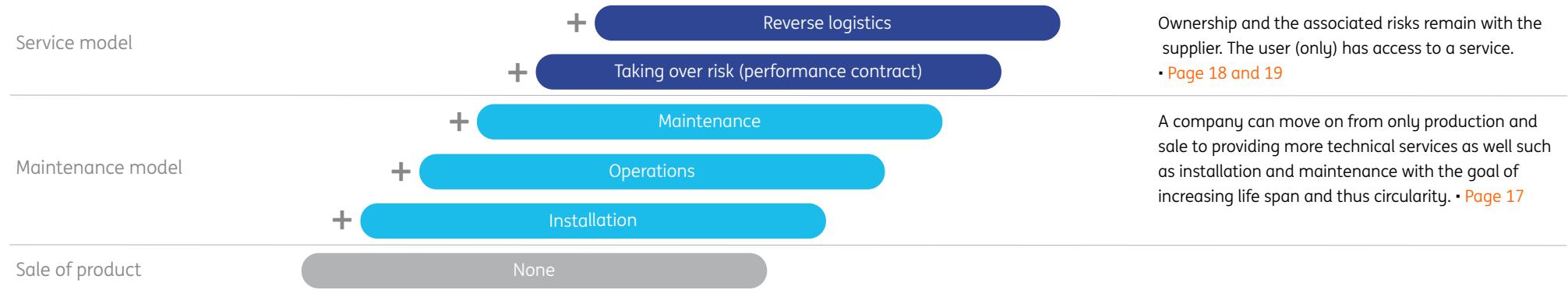
New business models encompassing 'from ownership to use'

In a circular model, all sorts of new business models can come into play. Maintenance becomes more important to lengthen the life span and manufacturers provide a service and no longer sell a product. The installer, for example, ensures a pleasant interior climate for several years and remains the owner of the systems. The idea behind this is that this gives the installer an added incentive to ensure high-grade use. In the construction sector, this is, however, often a step too far. We will explain this in the next pages.



In general, in the construction sector, it is mainly high-tech capital goods from the manufacturing sector that qualify for maintenance contracts or for 'from ownership to use'. More detail about this can be found in the ING report: [From assets to access](#).

Possible services on the road to circular construction



What role does 'from ownership to use' play?

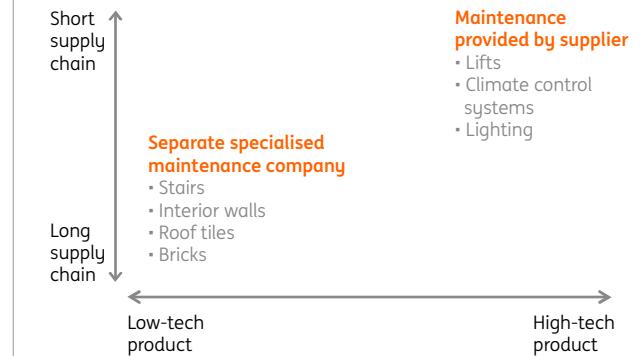
Maintenance contract more likely for smart buildings

Maintenance creates constant cash flow

Almost half the total European (EU 19) construction output comprises maintenance, renovations and repairs. This is a huge market with an annual turnover of more than € 700 billion¹. The advantage of the maintenance market is that it creates a stable cash flow and is less sensitive to fluctuations in the economy. Sound maintenance increases the life span of a building and thus increases the circularity because no new building materials have to be manufactured with the accompanying higher CO₂ emissions.

¹ Source: Euroconstruct

Maintenance contract for real estate best applied for technically complex products in a short supply chain



Many low-grade technical products

The maintenance of building materials is often relatively straightforward. This means that many companies can do this maintenance which does not involve technically complex products such as facades, the roof and interior walls. Often, the maintenance of these products is also limited. Systems (climate control systems and electricity) are much more complex as a result of which the supplier has a knowledge advantage and can provide the maintenance more efficiently.



Long lead times

The long lead times for real estate are often an obstacle to concluding maintenance contracts. This creates uncertainty and when there is low maintenance frequency needed, leads to prefinancing of the contractor.

Smart buildings as a driving force for maintenance

The arrival of smart buildings has increased the complexity of buildings. This widens the 'knowledge gap' between manufacturer and user and increases the applicability of the maintenance model. For example, suppliers have the opportunity to monitor and provide maintenance. In most cases, this is still periodic (1x a year inspection) and reactive (when there's a defect) maintenance. Sensors can provide the required information about a system, making maintenance much more predictable (predictive maintenance). This reduces failures and optimises maintenance planning.

What role does 'from ownership to use' play?

From ownership to use often a bridge too far

From ownership to use in a service model

A service model goes much further than a maintenance contract. Retention of ownership by the supplier or contractor is central here. The 'owner' of the building is only interested in using the materials. For example the 'owner' does not buy lights but 'light'. This leads to a shift of the risk and possibly financing towards the supplier or contractor.

A maintenance contract is most likely to succeed when the **value chain and lead times are short and when there is a high degree of technical complexity** (p. 17). For a service model to succeed, the following is also needed:



Simple ownership structure

When material is attached to the building, it is more complicated when the supplier or contractor retains ownership. What happens then from a legal point of view if one of the parties goes bankrupt? The law says that everything that is 'built-in' belongs to the building.



Performance must be easy to measure

Straightforward performance agreements can be made for some products. A lift works or does not work. However, the right climate in a building does not depend only on the climate control system but also on the insulation value of other materials and the user's conduct.



Low financing costs

Because the supplier or the contractor continues to be the owner of the products, they also have to finance these. When the financing costs exceed those of the owner/investor, the offer of a service model becomes more expensive.



High degree of flexibility

When the building is temporary, it is more logical for ownership to remain with the suppliers or contractor. They can then use the building materials again for other building projects and know the 'second hand' market. Another sort of flexibility that is needed is when adjustments need to be made to the building. The real estate owner needs flexibility for this; this flexibility is available when the real estate owner owns the entire building. There is no dependence on suppliers or current (lease) contracts that might not allow adjustment to their materials.

A care-free solution

The advantage of a service model for the buyer (owner of the building) is that the owner is supported and gets a better product for a fixed periodic user fee. Clearly defined performance agreements are made in advance. The risks relating to the uncertainties of the building materials remain largely with the supplier.

Service model often unsuitable for the construction sector

It is mainly high-tech building materials from the manufacturing sector that qualify for a service model in the construction sector (p. 19). For many other materials, a service model is not a logical choice because:

- They are attached to other materials.
- The ownership structure is complex.
- Performance is not easy to measure.
- Financing is often more expensive for the contractor or supplier than for the owner of the buildings.
- Few buildings are temporary.

What role does 'from ownership to use' play?

Examples of service models: likely/unlikely

Examples



Suitable for service model

Revolving doors in temporary office

- The technical complexity means the manufacturer can provide the maintenance.
- The performance can be easily measured.
- High degree of flexibility needed because the office is temporary.
- The doors can be defined relatively easily as a separate product. This makes the ownership structure relatively simple.

Inexpensive financing opportunities and the short value chain also makes the service model easier to apply.



Less suitable for service model

Precast units in dwelling

- A low-tech product that requires little maintenance.
- The required performance is difficult to measure and is highly dependent on other materials in the building.
- The required flexibility is low because homes are often built to last more than 50 years.
- The ownership structure is highly complex because the precast unit is part of the supporting structure.

Providing the 'vertical mobility service'

Mitsubishi Elevator Europe 'provides a service model for lifts with its M-Use®. In the concept, Mitsubishi continues to own the lift system and provides support to the end user. This is a deviation from the maintenance model in which the lift is purchased in combination with maintenance. M-Use® provides 'vertical mobility'.

Result agreements regarding the service are easy to make for the lift based on the maximum number of failures (one a year) and number of hours the lift is out of operation (15.5 a year). Lifts are relatively complex products meaning that Mitsubishi as supplier can exploit its knowledge advantage over other (maintenance) companies and is able to offer maintenance efficiently. Through the use of sensors, Mitsubishi knows exactly how often the lifts are used and through remote monitoring, it coordinates the maintenance programme perfectly with this actual use. While at the same time, the life span of the product is increased. Mitsubishi is a keen supporter of the reuse of lift parts and the recycling of materials to promote more circularity.

By creating a right of lien on the lift shaft, the **legal ownership structure** remains relatively simple. For the **financing** the user still pays the system costs at the start but these are much lower (up to half) than for traditional purchase. Additionally, the user pays an annual amount.





5. Conclusion

Winners and losers in the supply chain

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Conclusion

Winners and losers in the supply chain

Which supply chain partners profit most from the emergence of circular construction? The first companies to embrace the circular principles have a competitive advantage. However the growth potential differs vastly for the different partners:

Supply chain partner		Opportunities created by circular construction
 Demolisher	++	By 'dismantling' buildings rather than demolishing them and by selling high-grade building materials, the demolisher can deliver extra added value.
 Wholesaler in the construction sector	++	For wholesalers, opportunities lie in the reuse of materials. They can buy used building materials and create a materials bank through which they can sell these. The advantage of this for wholesalers is that they have a network of contractors to which they can sell these materials.
 Supplier of high-tech building materials	+	By offering a maintenance contract or a service model (p. 18 and 19), suppliers of high-tech applications can offer extra added value for circular construction.
 Real estate investor	+	Circular buildings offer added value. Demand among users is increasing (p. 9) and a building that can be converted for a different use easily and inexpensively increases the value. However, investors often do not see this value now because they have a relatively short investment vision and surveyors only have little appreciation of this added value, or none at all.
 Project developer	+/-	By tendering on the basis of performance standards and not on the basis of nailed-down specifications, project developers can promote circular innovation throughout the entire construction chain and therefore meet the increasing demand for circular construction among real estate investors and users.
 Architect	+/-	The architect designs differently (p. 12). The architect opts for sustainable building methods and materials and designs buildings that are easy to transform or dismantle. However, the architect's role in the supply chain is not changed by circular construction.
 Contractor	+/-	The contractor has to start building differently (p. 12). He uses different building methods and sustainable building materials and ensures that building materials are reused by buying these through the wholesaler or from demolishers. However, the contractor's role in the supply chain is not changed by circular construction. It is possible that there might be more emphasis on maintenance and renovation instead of on new buildings.
 Supplier of low-tech building materials	-	Due to less use being made of new building materials the demand for new low-tech building materials could fall. Providing maintenance or service contracts for these low-tech building materials is less likely to occur than for high-tech building materials.

Colophon

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New Horizon

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Ballast Nedam

BAM

ING Facility Management

Spaces4You

BAM

VMRG

ING Real Estate Finance

Mitsubishi Elevator Europe

BAM

ING Sustainability

Bouwbedrijf Ter Steege

Bureau Pluck

Bouwend Nederland

Van Wanrooij

Stichting C2C ExpoLAB